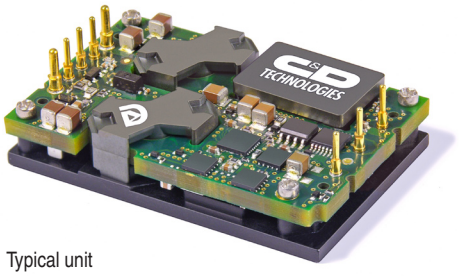
# UQQ Series

Wide Input Range Single Output DC/DC Converters



Typical unit

For applications requiring wide range input, improved electrical and thermal perfomance consider C&D's new UQQ Series "Quarter-Brick" DC/DC Converters. They measure just 1.45 x 2.30 x 0.43 inches (36.8 x 58.4 x 10.92mm) and fit the industry-standard footprint.

## FEATURES

- RoHS compliant
- Standard quarter-brick package/pinout in through-hole version
- Low cost; Low profile, 0.43"(10.92mm)
- 9-36V or 18-75V wide range inputs
- Output current: 7 to 25 Amps
- Output voltages: 3.3, 5, 12, 15 or 24V
- Interleaved synchronous-rectifier topology
  - Ultra high efficiency
  - No output reverse conduction
- Outstanding thermal performance
- On/off control, trim & sense functions
- Fully isolated, up to 2250Vdc (BASIC)
- Output overvoltage protection
- Fully I/O protected; Thermal shutdown
- UL/EN/IEC60950 safety approvals
- Designed for RoHS compliance

## PRODUCT OVERVIEW

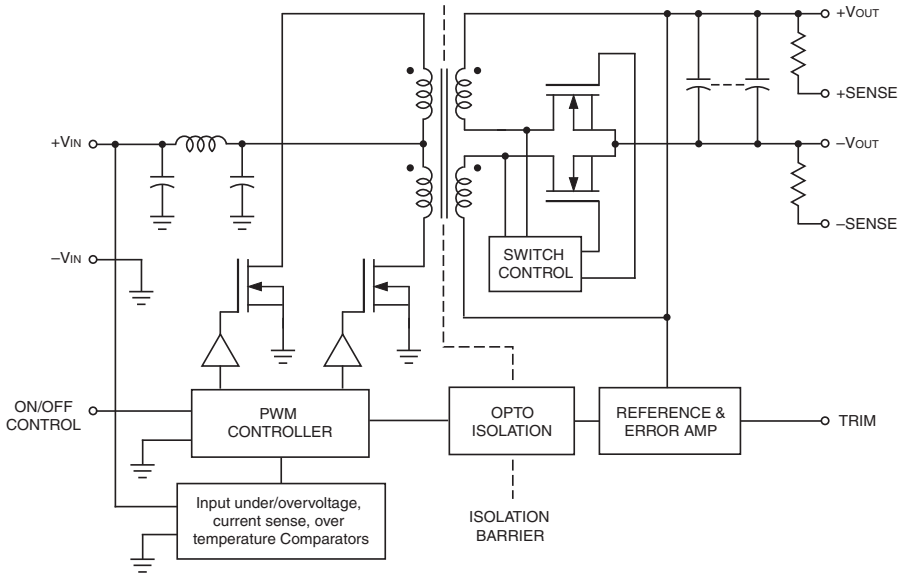
From an 9-36V or 18-75V input, UQQ's deliver outputs of 3.3V, 5V,12V,15V, or 24V. They employ an interleaved, synchronous-rectifier topology that exploits 100% of their duty cycle. They simultaneously achieve ultra-high efficiency (to 91%), tight line/load regulation, low noise, and quick step response.

A state of the art, single-board, open-frame design with reduced component count, high efficiency, low-on-resistance FET's, and planar magnetics embedded in heavy-copper pc boards all contribute to impressive thermal derating.

The UQQ's feature set includes high isolation, input pi filters, input undervoltage shutdown, output overvoltage protection, current limiting, short-circuit protection and thermal shutdown. The standard footprint carries on/off control (positive or negative polarity), output trim (+10/–20%) and output sense functions.

All UQQ quarter-bricks are designed to meet the BASIC-insulation requirements of UL/EN/IEC60950 and they will carry the CE mark. Safety certifications, EMC compliance testing and qualification testing (including HALT) are currently in progress. Contact C&D for latest updates.

## SIMPLIFIED SCHEMATIC




Typical topology is shown.

RoHS COMPLIANT 2002/95/EC

25

For full details go to www.cd4power.com/rohs

## PERFORMANCE SPECIFICATIONS AND ORDERING GUIDE

| Root Model ⑤ | Output | | | | | | | Input | | | | Efficiency | | Package (Case/ Pinout) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $V_{OUT}$ (V) | $I_{OUT}$ (A) | Power (W) | R/N (mVp-p) | | Regulation | | $V_{IN}$ Nom. (Volts) | Range (Volts) | $I_{IN}$, no load (mA) | $I_{IN}$, full load (A) | Min. | Typ. | |
| | | | | Typ. | Max. | Line | Load | | | | | | | |
| **UQQ-3.3/25-Q12** | 3.3 | 25 | 82.5 | 50 | 80 | ±0.05% | ±0.075% | 12 | 9-36 | 180 | 7.81 | 86% | 88% | C68,P32 |
| **UQQ-3.3/25-Q48** | 3.3 | 25 | 82.5 | 50 | 100 | ±0.05% | ±0.2% | 48 | 18-75 | 80 | 1.942 | 87% | 88.5% | C68,P32 |
| **UQQ-5/17-Q12** | 5 | 17 | 85 | 40 | 75 | ±0.05% | ±0.06% | 12 | 9-36 | 150 | 7.83 | 88.5% | 90.5% | C68,P32 |
| **UQQ-5/20-Q48** | 5 | 20 | 100 | 40 | 75 | ±0.05% | ±0.1% | 48 | 18-75 | 150 | 2.29 | 89.5% | 91% | C68,P32 |
| **UQQ-12/8-Q12** | 12 | 8 | 96 | 40 | 75 | ±0.05% | ±0.05% | 12 | 9-36 | 180 | 8.99 | 87% | 89% | C68,P32 |
| **UQQ-12/8-Q48** | 12 | 8 | 96 | 75 | 125 | ±0.05% | ±0.1% | 48 | 18-75 | 90 | 2.3 | 87% | 88.5% | C68,P32 |
| **UQQ-15/7-Q12** | 15 | 7 | 105 | 40 | 75 | ±0.05% | ±0.1% | 12 | 9-36 | 250 | 9.67 | 89% | 90.5% | C68,P32 |
| **UQQ-24/4-Q12** | 24 | 4 | 96 | TBD | TBD | TBD | TBD | 12 | 9-36 | TBD | TBD | TBD | TBD | C68,P32 |

① Typical at TA = +25°C under nominal line voltage and full-load conditions. All models are specified with an external 1µF multi-layer ceramic and 10µF capacitors across their output pins and 100µF external input capacitor.
② Ripple/Noise (R/N) measured over a 20MHz bandwidth.
③ Devices have no minimum-load requirements and will regulate under no-load conditions. Regulation specifications describe the output voltage deviation as the line voltage or load is varied from its nominal/midpoint value to either extreme. (Load step = 50%.)
④ Nominal line voltage, no load/full load condition.
⑤ These are incomplete part numbers, refer to the part number structure when ordering.

## PART NUMBER STRUCTURE

U QQ - 5 / 17 - Q12 N 9 B Lx - C

**Output Configuration**

**Quarter-Brick Package**

**Nominal Output Voltage**

**Maximum Rated Output**

**Input Voltage Range**

**Remote On/Off Control Polarity:**
Add "**P**" for positive polarity
Add "**N**" for negative polarity

**Baseplate Pin 9 (special order):**
9 = Pin 9 installed, connects to baseplate
Blank = No pin 9

**Baseplate:**
B = baseplate installed
Blank = no baseplate

**Pin Length Option**
**L1** = 0.110 (2.79mm)
**L2** = 0.145 (3.68mm)
**Blank** = Std. pin length

**RoHS-6 compliant**
(please include this designator for all models)

**Note:**
Not all model number combinations are available.
Contact C&D.

Some model options may require minimum order quantities.

### Pin 9 Baseplate Connection

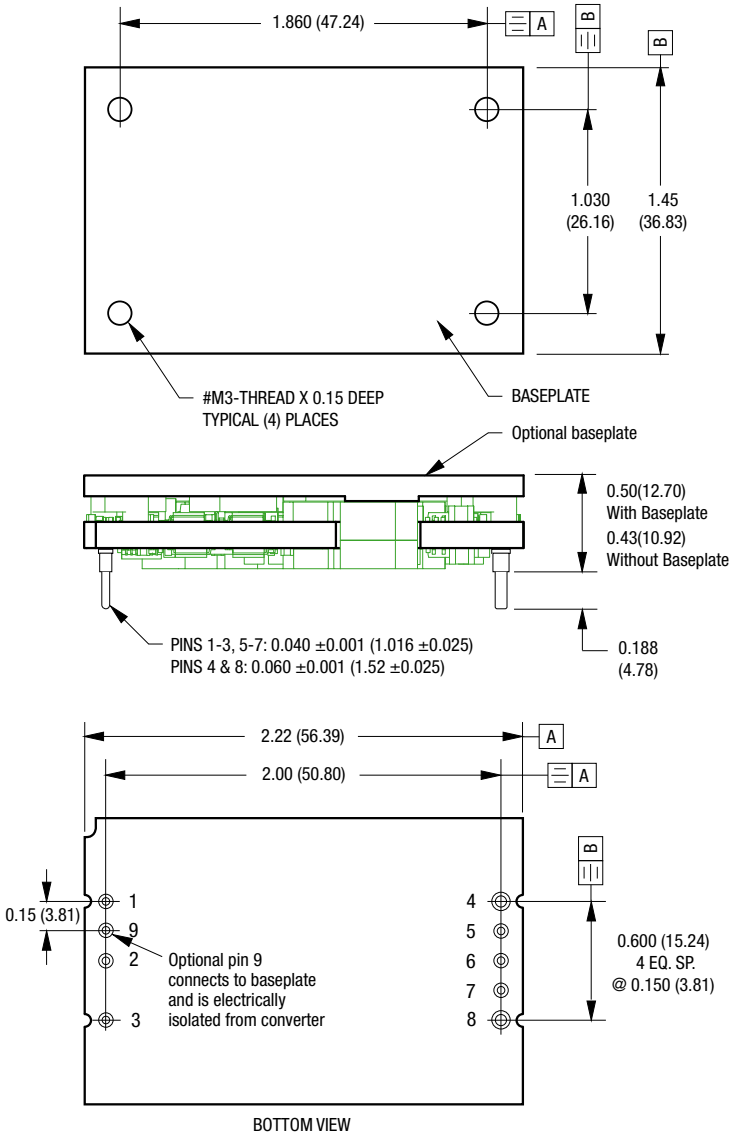
The UQQ series may include an optional installed baseplate for extended thermal management. This baseplate is electrically isolated from the rest of the converter. Various UQQ models are also available with an additional pin 9 on special quantity order which electrically connects to the baseplate. Pin 9 is also isolated from the rest of the converter. Please refer to the mechanical drawings.

Pin 9 offers a positive method of controlling the electrical potential of the baseplate, independent of the converter. If you do not include pin 9, the baseplate may also be grounded by the mounting bolts.

The baseplate may be ordered by adding a "B" to the model number tree and pin 9 will be pre-installed by adding a "9". The two options are separate. Please refer to the Ordering Guide. ***Do not order pin 9 without the baseplate.*** Note that "pin 9" converters may be on limited forecast, requiring minimum order quantities and scheduled deliveries.

Please see page 9 for heatsink information.

## MECHANICAL SPECIFICATIONS




| INPUT/OUTPUT CONNECTIONS | |
|---|---|
| **Pin** | **Function P32** |
| 1 | -Input |
| 2 | Remote On/Off* |
| 3 | +Input |
| 4 | -Output |
| 5 | -Sense |
| 6 | Output Trim |
| 7 | +Sense |
| 8 | +Output |
| 9 | Baseplate (optional) |

* The Remote On/Off can be provided with either positive ("P" suffix) or negative ("N" suffix) polarity.

All dimensions are in inches (mm)

## Performance and Functional Specifications (1)

| | UQQ-3.3/25-Q12 | UQQ-3.3/25-Q48 | UQQ-5/17-Q12 | UQQ-5/20-Q48 | UQQ-12/8-Q12 | UQQ-12/8-Q48 | UQQ-15/7-Q12 |
|---|---|---|---|---|---|---|---|
| **INPUT** | | | | | | | |
| **Input Voltage Range** | See ordering guide | | | | | | |
| **Start-up Threshold** | 9.0 Volts | 17.50 Volts | 9.0 Volts | 17.5 Volts | 9.0 Volts | 17.5 Volts | 9.0 Volts |
| **Undervoltage Shutdown** | 8.0 Volts | 16.75 Volts | 8.0 Volts | 16.75 Volts | 8.0 Volts | 16.0 Volts | 8.0 Volts |
| **Overvoltage Shutdown** | 40.0 Volts | NA | 37.5 Volts | None | 37 Volts | None | 38.5 Volts |
| **Reflected (back) ripple current** | 25mAp-p | 15mAp-p | 75mAp-p | 25mAp-p | 75mAp-p | 15mAp-p | 50mAp-p |
| **Input Current** | | | | | | | |
| Full load conditions | See ordering guide | | | | | | |
| Inrush transient | 0.1A²sec | 0.1A²sec | 0.1A²sec | 0.1A²sec | 0.1A²sec | 0.1A²sec | 0.1A²sec |
| Output short circuit | 250mA | 100mA | 100mA | 250mA | 250mA | 100mA | 250mA |
| No load | 150mA | 80mA | 150mA | 150mA | 180mA | 90mA | 250mA |
| Low line ($V_{IN}$ = min.) | 10.3 Amps | 5.04 Amps | 10.49 Amps | 6.11 Amps | 11.99 Amps | 5.96A | 10.20 Amps |
| Standby mode (Off, UV, OT shutdown) | 8mA | 2mA | 8mA | 8mA | 5mA | 2mA | 5mA |
| **Internal Input Filter Type** | LC | Pi-type | L-C | L-C | L-C | PI-type | L-C |
| **Reverse Polarity Protection** | Yes (15) | NA | Yes (15) | Yes (15) | Yes (15) | NA | Yes (15) |
| **Remote On/Off Control** (5) Positive logic ("P" suffix) | OFF = Ground pin to +0.8V max. ON = open or +3.5-15V max. | | | | | | |
| Negative logic ("N" suffix) | OFF = open or +5 to +$V_{IN}$ max. ON = Ground pin to +0.8V max. (16) | | | | | | |
| **Current** | 1 mA | 1 mA | 1 mA | 1mA | 1 mA | 1 mA | 1 mA |
| **OUTPUT** | | | | | | | |
| **Voltage Output Range** | See ordering guide | | | | | | |
| **Voltage Output Accuracy** | ±1% of $V_{NOM}$ (50% load) | ±1.25% of $V_{NOM}$ (50% load) | ±1% of $V_{NOM}$ (50% load) | ±1% of $V_{NOM}$ (50% load) | ±1% of $V_{NOM}$ (50% load) | ±1% of $V_{NOM}$ (50% load) | ±1.25% of $V_{NOM}$ (50% load) |
| **Adjustment Range** | –20 to +10% of $V_{NOM}$ | –15 to +10% of $V_{NOM}$ | –20 to +10% of $V_{NOM}$ | –20 to +10% of $V_{NOM}$ | –20 to +10% of $V_{NOM}$ | –20 to +10% of $V_{NOM}$ | –20 to +10% of $V_{NOM}$ |
| **Temperature Coefficient** | ±0.02% of $V_{OUT}$ range/°C | ±0.02% of $V_{OUT}$ range/°C | ±0.02% of $V_{OUT}$ range/°C | ±0.02% of $V_{OUT}$ range/°C | ±0.02% of $V_{OUT}$ range/°C | ±0.02% of $V_{OUT}$ range/°C | ±0.02% of $V_{OUT}$ range/°C |
| **Minimum Loading** | No minimum load | | | | | | |
| **Remote Sense Compensation** | +10% | +10% | +10% | +10% | +10% | +10% | +10% |
| **Ripple/noise (20MHz bandwidth)** | See ordering guide | | | | | | |
| **Line/Load Regulation** | | | | | | | |
| **Efficiency** | | | | | | | |
| **Maximum Capacitive Loading** Low ESR <0.02Ω max., resistive load | 10,000µF | 4700µF | 10,000µF | 10,000µF | 4700µF | 2200µF | 4700µF |
| **Isolation Voltage** | | | | | | | |
| Input to Output | 2000 Volts min. | 2250 Volts min. | 2000 Volts min. | 2250 Vvolts min. | 2250 Volts min. | 2250 Volts min. | 2000 Volts min. |
| Input fo baseplate | 1500 Volts min. | 1500 Volts min. | 1500 Volts min. | 1500 Volts min. | 1500 Volts min. | 1500 Volts min. | 1500 Volts min. |
| Baseplate to output | 1500 Volts min. | 500 Volts min. | 750 Volts min. | 750 Volts min. | 750 Volts min. | 500 Volts min. | 1500 Volts min. |
| Isolation resistance | 100MΩ | 100MΩ | 100MΩ | 100MΩ | 100MΩ | 100MΩ | 100MΩ |
| Isolation capacitance | 1500 pF | 1000 pF | 1500 pF | 1500pF | 1000 pF | 1000 pF | 1000 pF |
| Isolation safety rating | Basic insulation | Basic insulation | Basic insulation | Basic insulation | Basic insulation | Basic insulation | Basic insulation |
| Current limit inception (98% of Vout, after warmup) | 29 Amps | 29 Amps | 20.5 Amps | 25 Amps | 10 Amps | 10.5 Amps | 9.5 Amps |
| **Short Circuit Protection Method** | Current limiting, hiccup autorestart. Remove overload for recovery. | | | | | | |
| **Short Circuit Current** | 5 Amps | 5 Amps | 0.5 Amps | 5 Amps | 0.5 Amps | 5 Amps | 0.5 Amps |
| **Short Circuit Duration** | Continuous, output shorted to ground (no damage) | | | | | | |
| **Overvoltage Protection** via magnetic feedback | 4 Volts | 3.96 Volts max. | 6 Volts | 6 Volts | 14.4 Volts | 15 Volts | 18 Volts |

| | UQQ-3.3/25-Q12 | UQQ-3.3/25-Q48 | UQQ-5/17-Q12 | UQQ-5/20-Q48 | UQQ-12/8-Q12 | UQQ-12/8-Q48 | UQQ-15/7-Q12 |
|---|---|---|---|---|---|---|---|
| **DYNAMIC CHARACTERISTICS** | | | | | | | |
| **Dynamic Load Response** | 50µsec to ±1% of final value (50-75-50% load step) | 100µsec to ±1% of final value (50-75-50% load step) | 50µsec to ±1% of final value (50-75-50% load step) | 50µsec to ±1% of final value (50-75-50% load step) | 50µsec to ±1% of final value (50-75-50% load step) | 50µsec to ±1% of final value (50-75-50% load step) | 50µsec to ±1% of final value (50-75-50% load step) |
| **Start-up Time** | | | | | | | |
| $V_{IN}$ to $V_{OUT}$ regulated | 10msec | 50msec max. | 10msec | 10msec | 10msec | 20msec | 10msec |
| Remote On/Off to $V_{OUT}$ regulated | 5msec | 50msec max. | 5msec | 5msec | 5msec | 5msec | 5msec |
| Switching frequency | 255 ±25kHz | 200 ±20kHz | 260 ±25kHz | 255 ±25kHz | 260 ±25kHz | 245 ±20kHz | 260 ±25kHz |
| **ENVIRONMENTAL** | | | | | | | |
| **Calculated MTBF** (4) | TBC | TBC | TBC | TBC | TBC | TBC | TBC |
| **Operating Temperature Range** (Ambient) No baseplate, 300 lfm, no derating, vertical mount | –40 to +65º | –40 to +70ºC | –40 to +67°C | –40 to +30°C | –40 to +46°C | –40 to +57°C (200LFM, with basplate) | –40 to +52°C |
| With derating | See Derating curves | | | | | | |
| **Operating Temperature Range** with baseplate (no derating required) (3)(14) | –40 to +105ºC | –40 to +100ºC | –40 to +105°C | –40 to +105ºC | –40 to +105°C | –40 to +100°C | –40 to +105°C |
| **Storage Temperature Range** | –55 to +125ºC | –55 to +125°C | –55 to +125°C | –55 to +125ºC | –55 to +125°C | –55 to +125°C | –55 to +125°C |
| **Thermal Protection/Shutdown** | +120ºC | +120ºC | +120ºC | +120ºC | +120°C | +120°C | +120°C |
| **Relative humidity** | To +85°ºC/85% non-condensing | | | | | | |
| **PHYSICAL** | | | | | | | |
| Outline dimensions | See mechanical specifications | | | | | | |
| Baseplate material | Aluminum | | | | | | |
| Pin material | Copper alloy | | | | | | |
| Pin diameter | 0.04/0.062 inches, 1.016/1.524 mm | | | | | | |
| Weight | 1 ounce (28 grams) | | | | | | |
| Electromagnetic interference (conducted and radiated) (external filter required) | FCC part 15, class B, EN55022 | | | | | | |
| Safety | UL/cUL 60950, CSA-C22.2 No.60950, IEC/EN 60950 | | | | | | |
| Flammability | UL 94V-0 | | | | | | |

**Specification Notes:**

(1) All models are tested and specified with 300 lfm airflow, external 1 || 10µF ceramic/tantalum output capacitors and a 100µF external input capacitor. All capacitors are low ESR types. These capacitors are necessary to accommodate our test equipment and may not be required to achieve specified performance in your applications. All models are stable and regulate within spec under no-load conditions.

General conditions for Specifications are +25°C, $V_{IN}$ = nominal, $V_{OUT}$ = nominal, full load unless noted.

(2) Input Ripple Current is tested and specified over a 5Hz to 20MHz bandwidth. Input filtering is $C_{IN}$ = 33µF tantalum, $C_{BUS}$ = 220µF electrolytic,

$L_{BUS}$ = 12µH.

(3) Note that Maximum Power Derating curves indicate an average current at nominal input voltage. At higher temperatures and/or lower airflow, the DC/DC converter will tolerate brief full current outputs if the total RMS current over time does not exceed the Derating curve. All Derating curves are presented at sea level altitude. Be aware of reduced power dissipation with increasing density altitude.

(4) Mean Time Before Failure is calculated using the Telcordia (Belcore) SR-332 Method 1, Case 3, ground fixed conditions, $T_{PCBOARD}$ = +25°C, full output load, natural air convection.

(5) The On/Off Control may be driven with external logic or by applying appropriate external voltages which are referenced to Input Common. The On/Off Control Input should use either an open collector/open drain transistor or logic gate.

(6) Short circuit shutdown begins when the output voltage degrades approximately 2% from the selected setting.

(7) The outputs are not intended to sink appreciable reverse current. Sinking excessive reverse current may damage the outputs.

(8) Output noise may be further reduced by adding an external filter. See I/O Filtering and Noise Reduction.

(9) All models are fully operational and meet published specifications, including "cold start" at –40°C.

(10) Regulation specifications describe the deviation as the line input voltage or output load current is varied from a nominal midpoint value to either extreme.

(11) Alternate pin length and/or other output voltages are available under special quantity order.

(12) Overvoltage shutdown on 48V input models can be eliminated under special quantity order. OV shutdown can be deleted in order to comply with certain telecom reliability requirements. These requirements attempt continued operation despite significant input overvoltage.

(13) Do not exceed maximum power specifications when adjusting the output trim.

(14) Note that the converter may operate up to +105°C with the baseplate installed (+100°C for the UQQ-3.3/25-Q48). However, thermal self-protection occurs near +120°C Therefore, +105°C is recommended to avoid thermal shutdown.

(15) If reverse polarity is accidentally applied to the input, a body diode will become forward biased and will accept considerable current. To ensure reverse input protection, always connect an external input fuse in series with the $+V_{IN}$ input. Use approximately twice the full input current rating with nominal input voltage.

(16) For On/Off Control on negative-polarity UQQ-3.3/25-Q48N models, the maximum OFF mode control voltage is +13.5 Volts. For the ON mode, the range is pin grounded to +1 Volt max.

## Absolute Maximum Ratings

| | 12V models | 48V models |
|---|---|---|
| **Input Voltage** | | |
| Continuous | 0 to +36V | 0 to +75V |
| Transient (100msec) | +50V | +100V |

| | |
|---|---|
| **On/Off Control** | 0V min to +13.5V max. |
| **Input Reverse Polarity Protection** | See Fuse section |
| **Output Overvoltage** | VOUT +20% max. |
| **Output Current** [7] | Current-limited. Devices can withstand sustained short circuit without damage. |
| **Storage Temperature** | –55 to +125°C |
| **Lead Temperature** (soldering 10 sec. max.) | +280°C |

Absolute maximums are stress ratings. Exposure of devices to any of these conditions may adversely affect long-term reliability. Proper operation under conditions other than those listed in the Performance/Functional Specifications Table is not implied nor recommended.

## TECHNICAL NOTES

### Removal of Soldered UQQ's from Printed Circuit Boards

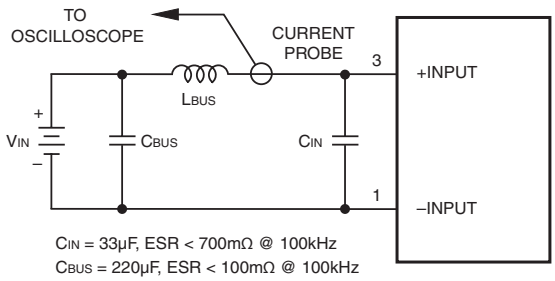
Should removal of the UQQ from its soldered connection be needed, thoroughly de-solder the pins using solder wicks or de-soldering tools. At no time should any prying or leverage be used to remove boards that have not been properly de-soldered first.

### Input Source Impedance

UQQ converters must be driven from a low ac-impedance input source. The DC/DC's performance and stability can be compromised by the use of highly inductive source impedances. The input circuit shown in Figure 2 is a practical solution that can be used to minimize the effects of inductance in the input traces. For optimum performance, components should be mounted close to the DC/DC converter.

### I/O Filtering, Input Ripple Current, and Output Noise

All models in the UQQ Series are tested/specified for input ripple current (also called input reflected ripple current) and output noise using the circuits and layout shown in Figures 2 and 3.




CIN = 33µF, ESR < 700mΩ @ 100kHz
CBUS = 220µF, ESR < 100mΩ @ 100kHz
LBUS = 12µH

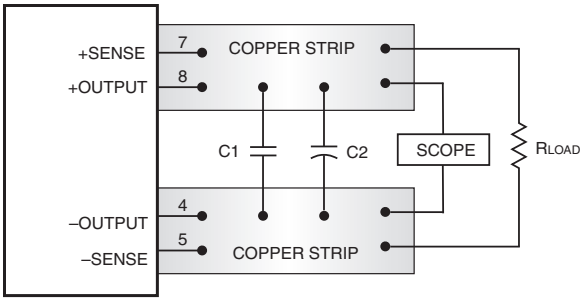
**Figure 2. Measuring Input Ripple Current**

External input capacitors (CIN in Figure 2) serve primarily as energy-storage elements. They should be selected for bulk capacitance (at appropriate frequencies), low ESR, and high rms-ripple-current ratings. The switching nature of DC/DC converters requires that dc voltage sources have low ac impedance as highly inductive source impedance can affect system stability. In Figure 2, CBUS and LBUS simulate a typical dc voltage bus. Your specific system configuration may necessitate additional considerations.

In critical applications, output ripple/noise (also referred to as periodic and random deviations or PARD) can be reduced below specified limits using filtering techniques, the simplest of which is the installation of additional external output capacitors. Output capacitors function as true filter elements and should be selected for bulk capacitance, low ESR, and appropriate frequency response. In Figure 3, the two copper strips simulate real-world pcb impedances between the power supply and its load. Scope measurements should be made using BNC connectors or the probe ground should be less than ½ inch and soldered directly to the fixture.

All external capacitors should have appropriate voltage ratings and be located as close to the converter as possible. Temperature variations for all relevant parameters should be taken into consideration. OS-CON™ organic semiconductor capacitors (www.sanyo.com) can be especially effective for further reduction of ripple/noise.

The most effective combination of external I/O capacitors will be a function of line voltage and source impedance, as well as particular load and layout conditions. Our Applications Engineers can recommend potential solutions and discuss the possibility of our modifying a given device's internal filtering to meet your specific requirements. Contact our Applications Engineering Group for additional details.




C1 = 1µF CERAMIC
C2 = 10µF TANTALUM
LOAD 2-3 INCHES (51-76mm) FROM MODULE

**Figure 3. Measuring Output Ripple/Noise (PARD)**

## Start-Up Threshold and Undervoltage Shutdown

Under normal start-up conditions, the UQQ Series will not begin to regulate properly until the ramping input voltage exceeds the Start-Up Threshold. Once operating, devices will turn off when the applied voltage drops below the Undervoltage Shutdown point. Devices will remain off as long as the undervoltage condition continues. Units will automatically re-start when the applied voltage is brought back above the Start-Up Threshold. The hysteresis built into this function avoids an indeterminate on/off condition at a single input voltage. See Performance/Functional Specifications table for actual limits.

## Start-Up Time

The $V_{IN}$ to $V_{OUT}$ Start-Up Time is the interval between the point at which a ramping input voltage crosses the Start-Up Threshold voltage and the point at which the fully loaded output voltage enters and remains within its specified accuracy band. Actual measured times will vary with input source impedance, external input capacitance, and the slew rate and final value of the input voltage as it appears to the converter. The On/Off to $V_{OUT}$ start-up time assumes that the converter is turned off via the Remote On/Off Control with the nominal input voltage already applied.

## On/Off Control

The primary-side, Remote On/Off Control function (pin 2) can be specified to operate with either positive or negative polarity. Positive-polarity devices ("P" suffix) are enabled when pin 2 is left open or is pulled high. Positive-polarity devices are disabled when pin 2 is pulled low (with respect to –Input). Negative-polarity devices are off when pin 2 is high and on when pin 2 is pulled low. See Figure 4

Dynamic control of the remote on/off function is best accomplished with a mechanical relay or an open-collector/open-drain drive circuit (optically isolated if appropriate). The drive circuit should be able to sink appropriate current (see Performance Specifications) when activated and withstand appropriate voltage when deactivated.

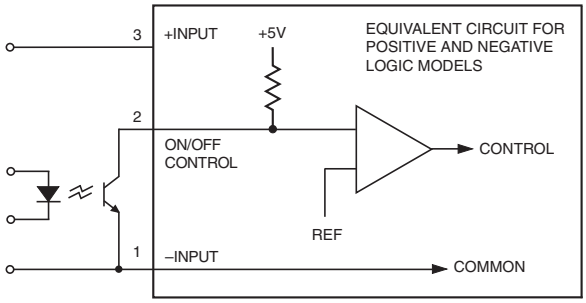



**Figure 4. Driving the Remote On/Off Control Pin**

## Sense Input

Use the Sense input with caution. Many applications do not need the Sense connection. Sense is intended to correct small output accuracy errors caused by the resistive ohmic drop in output wiring as output current increases. This output drop (the difference between Sense and $V_{OUT}$ when measured at the converter) should not be allowed to exceed 0.5V. Consider using heavier wire if this drop is excessive.

Sense is connected at the load and corrects for resistive errors only. Be careful where it is connected. Any long, distributed wiring and/or significant inductance introduced into the Sense control loop can adversely affect overall system stability. If in doubt, test the application, and observe the DC/DC's output transient response during step loads. There should be no appreciable ringing or oscillation. You may also adjust the output trim slightly to compensate for voltage loss in any external filter elements. Do not exceed

## Current Limiting

When power demands from the output falls within the current limit inception range for the rated output current, the DC/DC converter will go into a current
limiting mode. In this condition the output voltage will decrease proportionately with increases in output current, thereby maintaining a somewhat constant power dissipation. This is commonly referred to as power limiting. Current limit inception is defined as the point where the full-power output voltage falls below the specified tolerance. If the load current being drawn from the converter is significant enough, the unit will go into a short circuit condition. See “Short Circuit Condition.”

## Short Circuit Condition

When a converter is in current limit mode the output voltages will drop as the output current demand increases. If the output voltage drops too low, the magnetically coupled voltage used to develop primary side voltages will also drop, thereby shutting down the PWM controller. Following a time-out period of about 50 milliseconds, the PWM will restart, causing the output voltages to begin ramping to their appropriate values. If the short-circuit condition persists, another shutdown cycle will be initiated. This on/off cycling is referred to as “hiccup” mode. The hiccup cycling reduces the average output current, thereby preventing internal temperatures from rising to excessive levels. The UQQ is capable of enduring an indefinite short circuit output condition.

## Thermal Shutdown

UQQ converters are equipped with thermal-shutdown circuitry. If the internal temperature of the DC/DC converter rises above the designed operating temperature (See Performance Specifications), a precision temperature sensor will power down the unit. When the internal temperature decreases below the threshold of the temperature sensor, the unit will self start.

## Output Overvoltage Protection

The output voltage is monitored for an overvoltage condition via magnetic coupling to the primary side. If the output voltage rises to a fault condition, which could be damaging to the load circuitry (see Performance Specifications), the sensing circuitry will power down the PWM controller causing the output voltage to decrease. Following a time-out period the PWM will restart, causing the output voltage to ramp to its appropriate value. If the fault condition persists, and the output voltages again climb to excessive levels, the overvoltage circuitry will initiate another shutdown cycle. This

## Input Reverse-Polarity Protection

If the input-voltage polarity is accidentally reversed, an internal diode will become forward biased and likely draw excessive current from the power source. If the source is not current limited or the circuit appropriately fused, it could cause permanent damage to the converter.

## Input Fusing

Certain applications and/or safety agencies may require the installation of fuses at the inputs of power conversion components. Fuses should also be used if the possibility of a sustained, non-current-limited, input-voltage polarity reversal exists. For C&D UQQ Series DC/DC Converters, slow-blow fuses are recommended with values no greater than twice the maximum input current.

## Trimming Output Voltage

UQQ converters have a trim capability (pin 6) that enables users to adjust the output voltage from +10% to –20% (refer to the trim equations). Adjustments to the output voltage can be accomplished with a single fixed resistor as shown in Figures 5 and 6. A single fixed resistor can increase or decrease the output voltage depending on its connection. Resistors should be located close to the converter and have TCR's less than 100ppm/°C to minimize sensitivity to changes in temperature. If the trim function is not used, leave the trim pin open.

Standard UQQ's have a "positive trim" where a single resistor connected from the Trim pin (pin 6) to the +Sense (pin 7) will increase the output voltage. A resistor connected from the Trim Pin (pin 6) to the –Sense (pin 5) will decrease the output voltage.

Trim adjustments greater than the specified +10%/–20% can have an adverse affect on the converter's performance and are not recommended. Excessive voltage differences between $V_{OUT}$ and Sense, in conjunction with trim adjustment of the output voltage, can cause the overvoltage protection circuitry to activate (see Performance Specifications for overvoltage limits).

Temperature/power derating is based on maximum output current and voltage at the converter's output pins. Use of the trim and sense functions can cause output voltages to increase, thereby increasing output power beyond the UQQ's specified rating, or cause output voltages to climb into the output overvoltage region. Therefore:

($V_{OUT}$ at pins) x ($I_{OUT}$) ≤ rated output power

The Trim pin (pin 6) is a relatively high impedance node that can be susceptible to noise pickup when connected to long conductors in noisy environments. In such cases, a 0.22µF capacitor to –Output can be added to reduce this long lead effect.

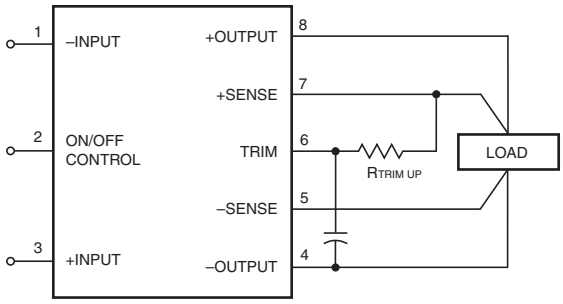



**Figure 5. Trim Connections To Increase Output Voltages Using Fixed Resistors**

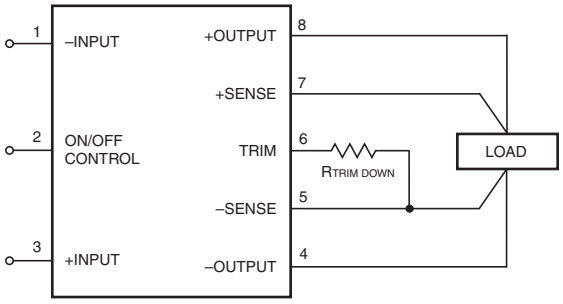
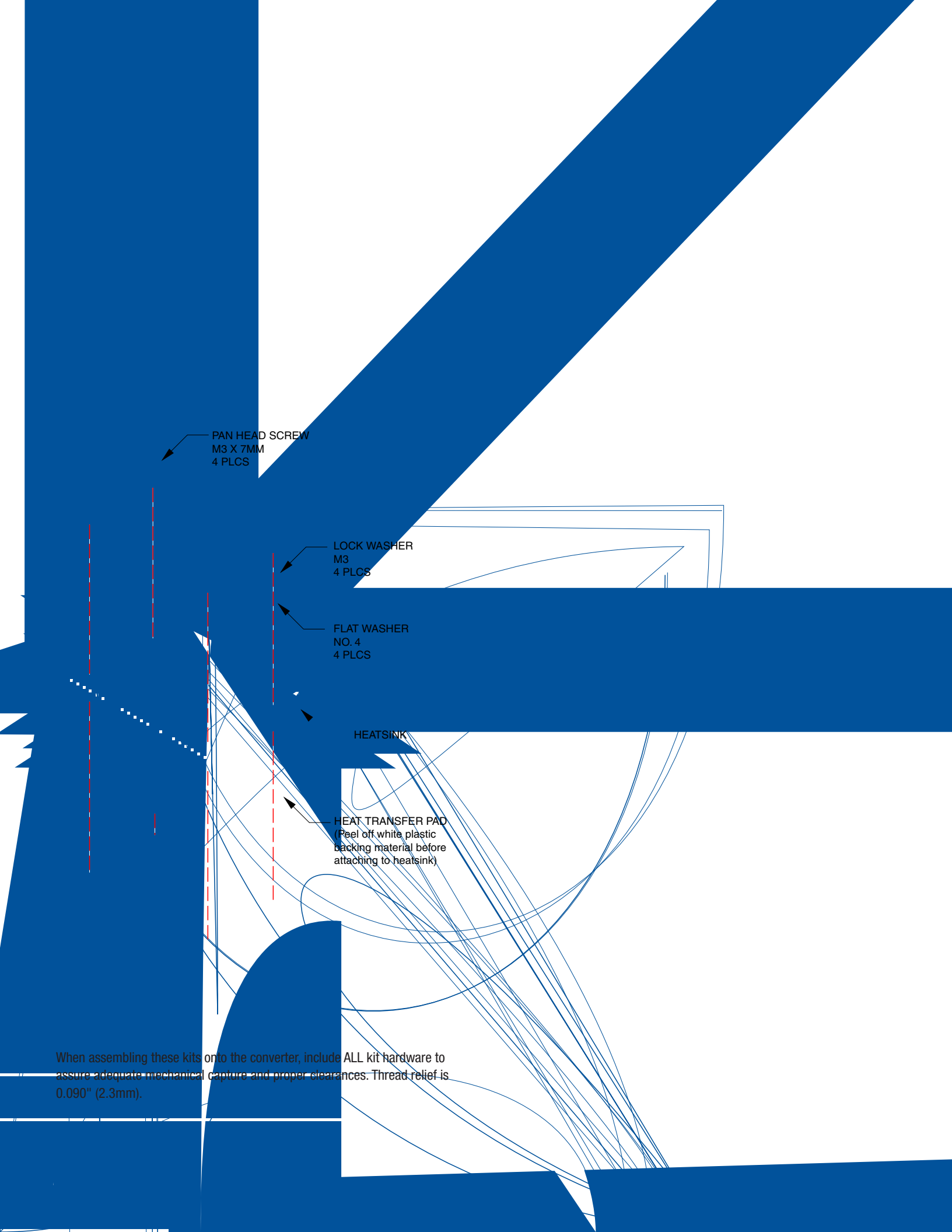



**Figure 6. Trim Connections To Decrease Output Voltages Using Fixed Resistors**

| Trim Up | Trim Down |
|---|---|
| **UQQ-3.3/25-Q48** | |
| $R_{T_{UP}}(k\Omega) = \frac{13.3(V_O - 1.226)}{V_O - 3.3} - 10.2$ | $R_{T_{DOWN}}(k\Omega) = \frac{16.31}{3.3 - V_O} - 10.2$ |
| **UQQ-5/17-Q12, UQQ-5/20-Q48** | |
| $R_{T_{UP}}(k\Omega) = \frac{20.4(V_O - 1.226)}{V_O - 5} - 10.2$ | $R_{T_{DOWN}}(k\Omega) = \frac{25.01}{5 - V_O} - 10.2$ |
| **UQQ-12/8-Q12, -Q48** | |
| $R_{T_{UP}}(k\Omega) = \frac{49.6(V_O - 1.226)}{V_O - 12} - 10.2$ | $R_{T_{DOWN}}(k\Omega) = \frac{60.45}{12 - V_O} - 10.2$ |
| **UQQ-15/7-Q12** | |
| $R_{T_{UP}}(k\Omega) = \frac{62.9(V_O - 1.226)}{V_O - 15} - 10.2$ | $R_{T_{DOWN}}(k\Omega) = \frac{76.56}{15 - V_O} - 10.2$ |




When assembling these kits onto the converter, include ALL kit hardware to assure adequate mechanical capture and proper clearances. Thread relief is 0.090" (2.3mm).

## Calculating Maximum Power Dissipation

To determine the maximum amount of internal power dissipation, find the ambient temperature inside the enclosure and the airflow (in Linear Feet per Minute – LFM) at the converter. Determine the expected heat dissipation using the Efficiency curves and the converter Input Voltage. You should also compensate for lower atmospheric pressure if your application altitude is considerably above sea level.

The general proceedure is to compute the expected temperature rise of the heatsink. If the heatsink exceeds +100°C. either increase the airflow and/or reduce the power output. Start with this equation:

**Internal Heat Dissipation [Pd in Watts] = (Ts – Ta)/RΘ [at airflow] [6]**

where "Ta" is the enclosure ambient air temperature and,

where "Ts" is the heatsink temperature and,

where "RΘ [at airflow]" is a specific heat transfer thermal resistance (in degrees Celsius per Watt) for a particular heat sink at a set airflow rate. We have already estimated RΘ [at airflow] in the equations above.

Note particularly that Ta is the air temperature inside the enclosure at the heatsink, not the outside air temperature. Most enclosures have higher internal temperatures, especially if the converter is "downwind" from other heat-producing circuits. Note also that this "Pd" term is only the internal heat dissipated inside the converter and not the total power output of the converter.

We can rearrange this equation to give an estimated temperature rise of the heatsink as follows:

**Ts = (Pd x RΘ [at airflow]) + Ta [7]**

## Heat Sink Example

Assume an efficiency of 92% and power output of 100 Watts. Using equation [4], Pd is about 8.7 Watts at an input voltage of 48 Volts. Using +30°C ambient temperature inside the enclosure, we wish to limit the heat sink temperature to +90°C maximum baseplate temperature to stay well away from thermal shutdown. The +90°C. figure also allows some margin in case the ambient climbs above +30°C or the input voltage varies, giving us less than 92% efficiency. The heat sink and airflow combination must have the following characteristics:

8.7 W = (90-30) / RΘ[airflow] or,

RΘ[airflow] = 60/8.7 = 6.9°C/W

Since the ambient thermal resistance of the heatsink and pad is 12.5°C/W, we need additional forced cooling to get us down to 6.9°C/W. Using a hypothetical airflow constant of 0.005, we can rearrange equation [5] as follows:

(Required Airflow, LFM) x (Airflow Constant) = RΘ[Nat.Convection] / RΘ[at airflow] –1

or,

(Required Airflow, LFM) x (Airflow Constant) = 12.5/6.9 –1 = 0.81

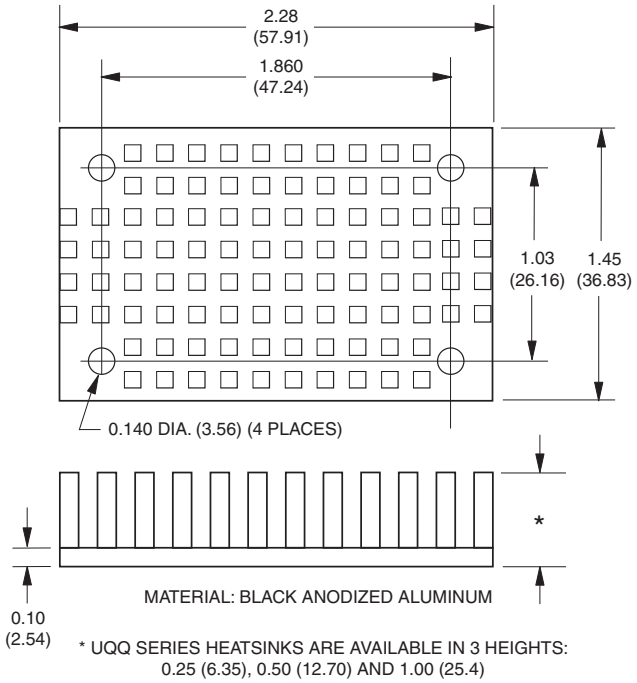
and, rearranging again,

(Required Airflow, LFM) = 0.81/0.005 = 162 LFM

162 LFM is the minumum airflow to keep the heatsink below +90°C. Increase the airflow to several hundred LFM to reduce the heatsink temperature further and improve life and reliability.

| Heatsink Kit * Model Number | Still Air (Natural convection) thermal resistance | Heatsink height (see drawing) |
|---|---|---|
| HS-QB25-UVQ | 12°C/Watt | 0.25" (6.35mm) |
| HS-QB50-UVQ | 10.6°C/Watt | 0.50" (12.7mm) |
| HS-QB100-UVQ | 8°C/Watt | 1.00" (25.4mm) |
| * Kit includes heatsink, thermal pad and mounting hardware. | | |

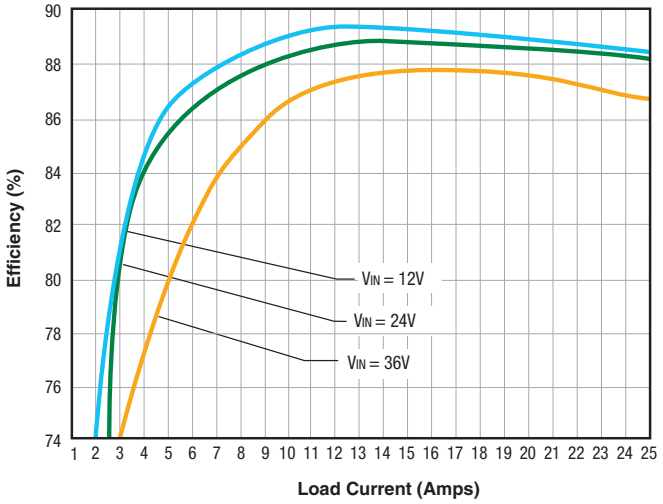
These model numbers are correct for the UQQ series.



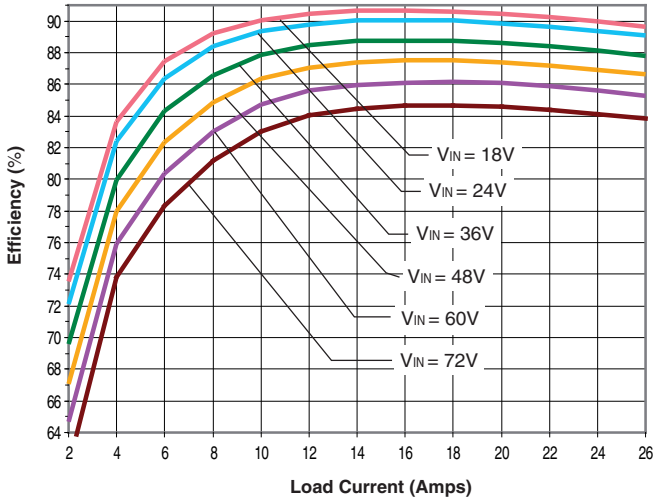

**Optional Heatsink**

## Typical Performance Curves

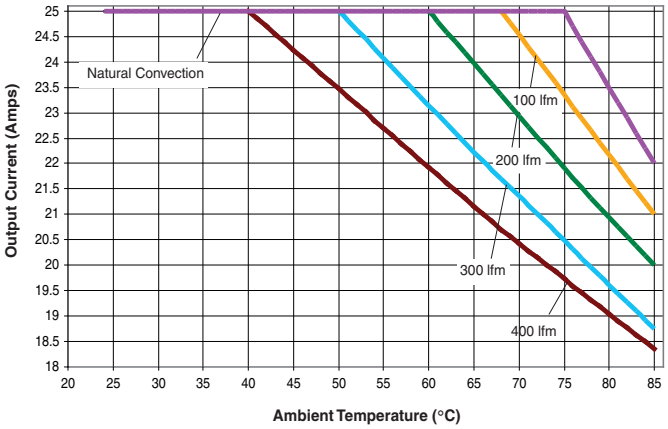
**UQQ-3.3/25-Q12**
**Efficiency vs. Line Voltage and Load Current @ 25°C**



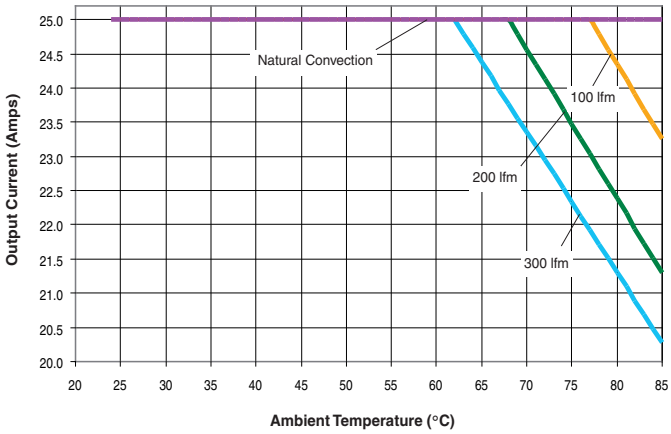

**UQQ-3.3/25-Q48P**
**Efficiency vs. Line Voltage and Load Current @ 25ºC**



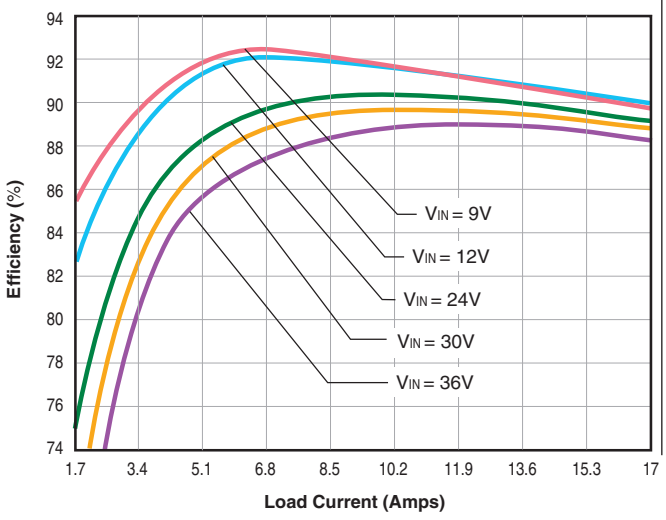

**UQQ-3.3/25-Q12P Maximum Current Temperature Derating**
(no baseplate, $V_{IN}$ = 12V, air flow is transverse)



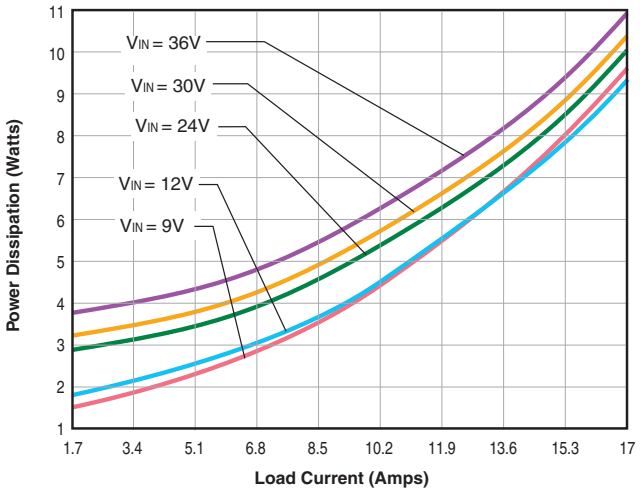

**UQQ-3.3/25-Q12PB Maximum Current Temperature Derating**
(with baseplate, $V_{IN}$ = 12V, air flow is transverse)




**UQQ-5/17-Q12P**
**Efficiency vs. Line Voltage and Load Current @ 25°C**

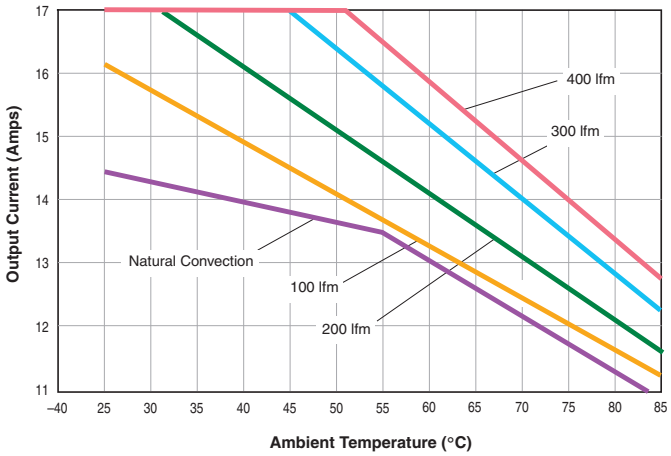



**UQQ-5/17-Q12P**
**Power Dissipation vs. Load Current @ 25°C**

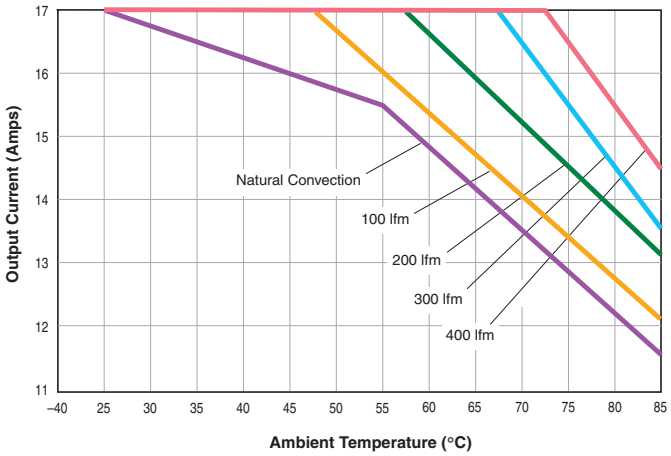


## Typical Performance Curves

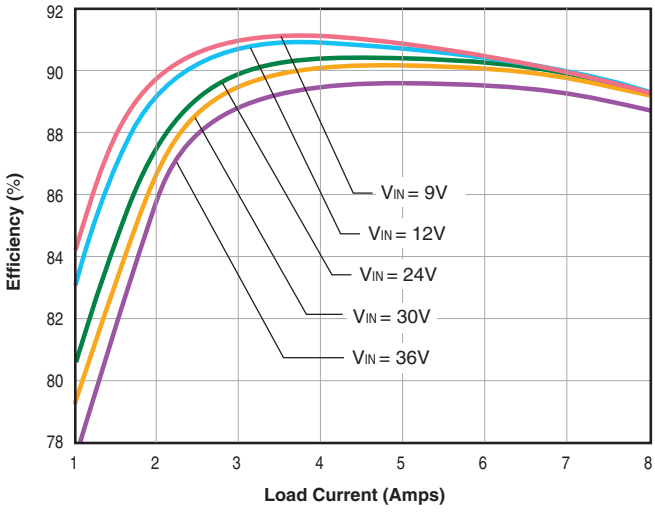
**UQQ-5/17-Q12P Maximum Current Temperature Derating**
No baseplate, $V_{IN}$ = 12V (transverse air flow at sea level)



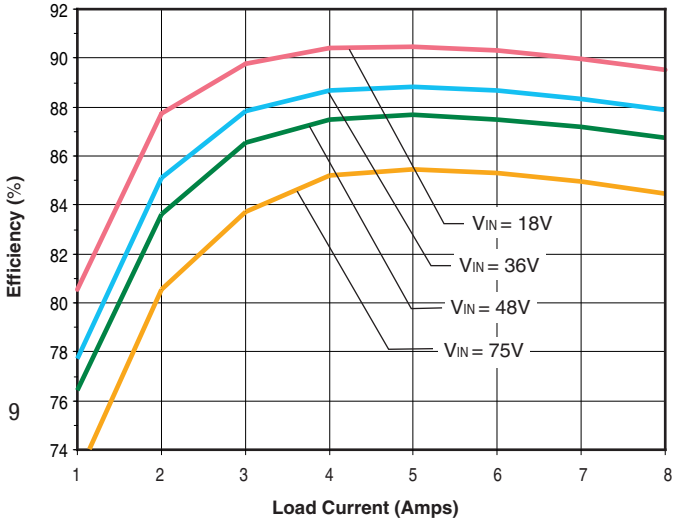

**UQQ-5/17-Q12P Maximum Current Temperature Derating**
With baseplate, $V_{IN}$ = 12V (transverse air flow at sea level)



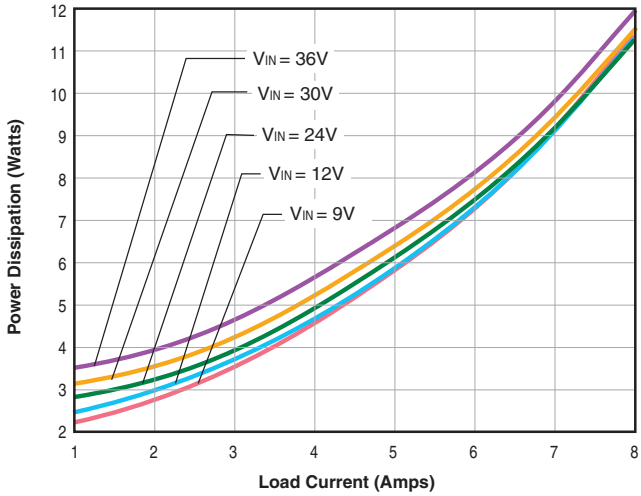

**UQQ-12/8-Q12P**
**Efficiency vs. Line Voltage and Load Current @ 25°C**



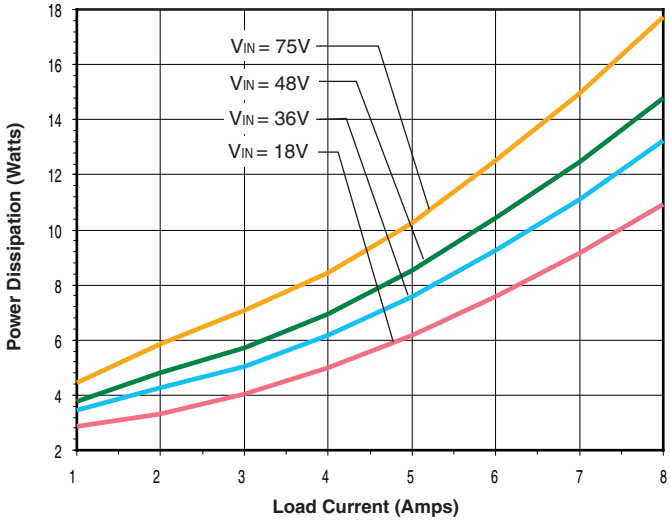

**UQQ-12/8-Q48P**
**Efficiency vs. Line Voltage and Load Current @ 25°C**

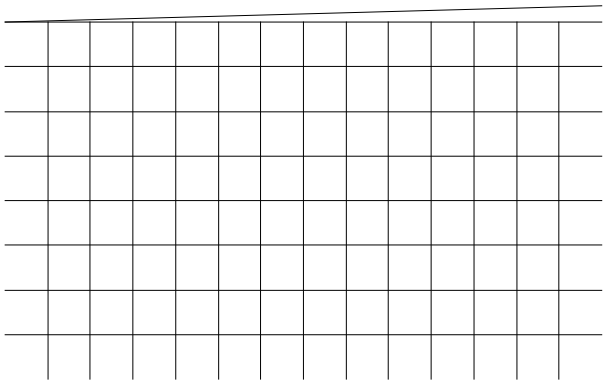



**UQQ-12/8-Q12**
**Power Dissipation vs. Load Current @ 25°C**



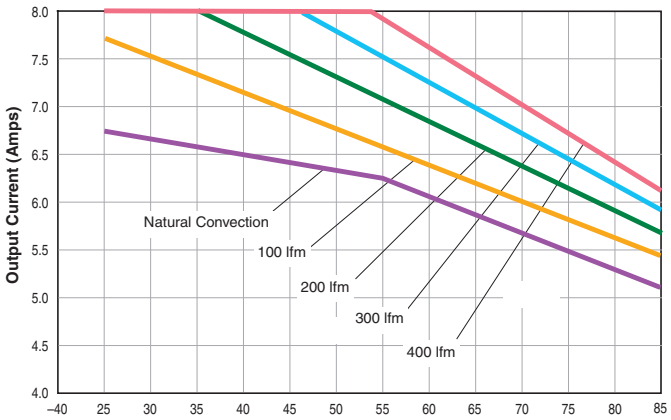

**UQQ-12/8-Q12**
**Power Dissipation vs. Load Current @ 25°C**





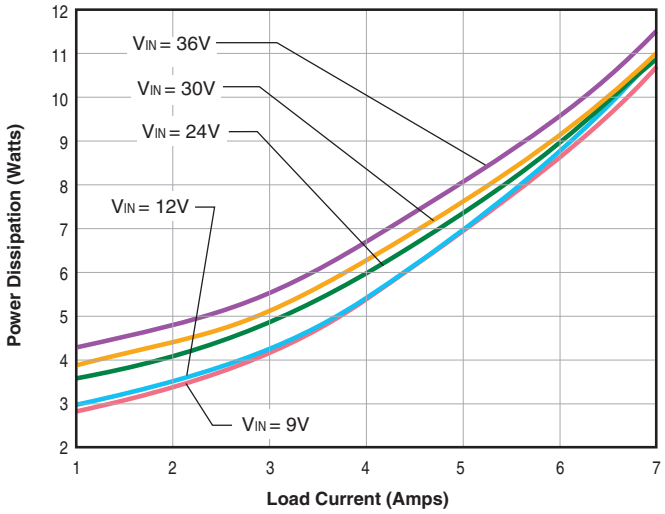
UQQ-15/7-Q12P

**UQQ-12/8-Q12P Maximum Current Temperature Derating**
With baseplate, $V_{IN}$ = 12V (transverse air flow at sea level)



## Typical Performance Curves

**UQQ-15/7-Q12P**
**Power Dissipation vs. Load Current @ 25°C**

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DS-0553 07/03/07

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